REPORT ON SOME CARBONIC ACID TESTS ON THE WEATHERING OF MARBLES AND LIMESTONES.

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The tests registered below were made with a view of determining not merely the relative solubility of certain calcareous rocks used for building and ornamental work, but as well, the manner in which the solvent acted. The ultimate aim of the experiments, as is obvious, was to ascertain how the stones would withstand the effects of an atmosphere and its rainfall made acid through absorbed carbonic acid. To make the results appreciable within a reasonable time, it was of course necessary to exaggerate the conditions. The process was as follows: Two samples of each stone selected were cut into the form of cubes approximately an inch in diameter, though without any attempt at exact correspondence in weight. How close the approximation is shown in the accompanying table of results.

The surfaces of each cube were rubbed with flour of emery on a glass plate as smooth as the nature of the material permitted, but no attempt was made to polish. They were then thoroughly washed and dried at 100° C. The cubes were then suspended by threads, in each case passed but once around the cube, in a large jar of water kept acid by a stream of carbonic acid from a charged cylinder. The water was changed once each week. No attempt was made to have the stream of bubbles constant and continuous, but the direction was changed occasionally to make certain that all were subjected to like conditions. Twice during the trial the cubes were withdrawn and while still suspended dried out by artificial heat and again immersed. At the end of 3 months they were all withdrawn, dried at a temperature of 100 degrees, and brushed off with a soft fitch brush to remove any loosened granules or dust. The appearance of each cube was carefully noted as to color changes as well as to the manner in which the solvent acted. The tables below give the weight of the cubes before and after and the loss of material both in weight and in percentage amounts. The first table gives the results of some preliminary tests which were not carried to completion, owing to imperfection of apparatus. They are, however, included here, since so far as they go they are confirmatory of those in the second. The results in both cases agree surprisingly well. It will be noted that while the amount of material lost in the first series is less than in the second, owing to the shorter period of trial, the two are always in accord. The amount of material lost by solution is not, however,

the sole item of importance, nor indeed the item of most importance. It will be noted that in some instances a stone losing a certain amount still retains a nearly smooth surface and sharp arrises. Others become roughened, granules loosened to the point of falling away, and the arrises as a consequence left ragged. In some of the stones there is a tendency for the smaller interstitial crystals to disappear, leaving the larger standing in relief. The Tennessee samples tested are of the gray and pink spotted varieties. In these the tinted calcite, which, judged from the forms, represents fragmental fossil material, is more refractory than the colorless and is left in slight relief. In the case of the oolitic limestones the oolites are eaten out, leaving the crystalline or interstitial material and the fossil fragments in relief, the outline of the oolite being sometimes preserved by the insoluble impurities. The considerable amount of insoluble material set free from these oolitic cubes during the trial settling to the bottom of the jar as mud or remaining to be brushed off the surface when the cube was dried seems to have come wholly from the oolites, and not from the interstices. It will be noted, as might have been expected, that the dolomitic marbles were not appreciably affected and that the oolitic stones lost during the trial an amount two and three times as great as that of any other of the stones tested. In but one instance was there any marked change in color in any of the samples.

TABLE 1.

PRELIMINARY TRIAL EXTENDING OVER PERIOD OF 70 DAYS.

Kind and locality.	Weight before trial in grams.	Weight after trial in grams.	Loss of weight in grams.	Percentage loss of weight.	Remarks.
White crystalline limestone: Marble, Yule, Colorado.	45.053 44.313	44.7075 43.8815	0.3455 0.4325	0.0077 .0097	Very slightly roughened; no granulation.
White crystalline limestone: Marble, Pickens County, Georgia.	42.3935 42.747	41.935 42.3565	0.4585 0.3905	.011 .009	Slightly roughened; no granulation.
White crystalline limestone: Marble, West Grove, Pennsylvania.	46.3455 44.7015	46.2345 44.586	0.1110 0.1155	.0024 .0026	Effect scarcely appreciable.
Pink crystalline limestone: Marble, Knoxville, Tennessee.	50.4485 48.478	49.904 47.9725	0.5445 0.5055	.0108 .0104	White portions slightly etched, leaving the pink standing in relief.
Gray crystalline limestone: Marble, Concord, Tennessee.	45.1075	44.4765	0.6310	.012	White portions slightly etched, leaving the pink standing in relief.
White crystalline limestone: Marble, Rutland, Vermont.	40.6655 41.1245	40.1185 40.432	0.547 0.6925*	.013 .016	Surfaces appreciably roughened.
Blue crystalline limestone: Marble, Rutland, Vermont.	44.444 41.0555	43.8355 40.589	0.6085 0.4665	.015 .011	Surfaces appreciably roughened: no granulation.
White crystalline limestone: Marble, Carrara, Italy.	38.6165 40.5885	38.114 40.0925	0.5025 0.496	.013 .012	Surfaces appreciably roughened; like white Rutland.
White crystalline dolomite: Marble, Cockeysville, Maryland	38.80 36.507	38.7755 36.4855	0.029 0.0215	.00062 .00058	Not appreciably acted upon.
White crystalline dolomite: Marble, Tuckahoe, New York.	42.0655 41.405	42.0415 41.3795	0.0240 0.0255	.00056 .0006	Not appreciably acted upon.
Oolitic limestone, Bedford, Indiana.	43.5785 41.1475	42.2435 39.8795	1.335 1.268	.0304 .0308	Distinctly roughened and pitted, the fossil fragments left standing in relief.
Oolitic limestone: Bowling Green, Kentucky.	41.1655 37.8355	40.504 37.1725	0.6115 0.663	.014 .017	Distinctly roughened and pitted, the oolites being eaten out, leaving surface covered by circular and oval pits often with a slight residual eminence in center.

TABLE II.

SECOND TRIAL EXTENDING OVER PERIOD OF THREE MONTHS.

Kind of stone and locality.	Original weight in grams.	Final weight in grams.	Loss of weight in grams.	Percentage loss in weight.	Remarks.
White crystalline limestone: Marble, Yule Creek, Colorado.	51.551 48.194	50.6465 47.2465	0.9045 0.9475	0.017 .019	A very slight roughening of the surface, but no granulation and but slightly attacked on the edges or arrises.
White crystalline limestone: Marble, Pickens County, Georgia.	44.034 43.6675	43.315 42.946	0.719 0.7215	.0165 .017	Surfaces very slightly roughened, but no granulation.
White crystalline limestone: Marble, Cherokee County, Georgia.	43.3885 44.400	42.7335 43.683	0.655 0.717	.015 .016	Surfaces very slightly roughened, a slight yellowing.
White crystalline limestone: Marble, West Grove, Pennsylvania.	47.8385 47.9695	47.615 47.768	0.2235 0.2015	.0047 .0042	Surfaces roughened, but no granulation.
White crystalline limestone: Marble, Proctor, Vermont.	44.4945 44.1085	43.62 43.3125	0.8745 0.796	.019 .018	Surfaces distinctly roughened and granulated, small particles loosened and falling away when handled or brushed; arrises roughened.
White crystalline limestone: Marble, Proctor, Vermont.	44.974 45.172	43.9295 44.001	1.0445 1.171	.023 .026	
White crystalline limestone: Marble, Pittsfield, Vermont.	42.536 43.97	41.705 42.9715	0.831 0.9985	.019 .022	
White crystalline limestone: Marble, Carrara, Italy.	43.5085 42.462	42.598 41.4885	0.9105 0.9735	.021 .023	Surfaces distinctly roughened and granulated, small particles loosened and breaking away when handled or brushed; arrises strongly attacked.
Gray crystalline limestone: Marble, Knoxville, Tennessee.	46.796 45.1725	45.8765 44.2975	0.9245 0.875	.019 .019	Surfaces roughened by the corrosion of the colorless granules leaving the pink tinted standing in relief. No granulation or mechanical loosening of particles.
Gray crystalline limestone: Marble, Knoxville, Tennessee.	44.069 44.3095	43.226 43.4545	0.843 0.855	.019 .019	
Gray crystalline limestone: Marble, Knoxville, Tennessee.	45.7165 45.5565	44.52 44.609	1.1965 0.9475	.026 .021	
Pink crystalline limestone: Marble, Concord, Tennessee.	42.7345 42.9635	41.808 42.1675	0.9265 0.796	.021 .0185	
White crystalline dolomite: Marble, Cockeysville, Maryland.	40.724 38.4355	40.687 38.3995	0.037 0.036	.00091 .00093	No perceptible change.
White crystalline dolomite: Marble, Berkshire, Massachusetts.	45.529 45.052	44.8385 44.378	0.6905 0.674	.015 .015	Surfaces distinctly roughened by corrosion along planes of cleavage and color changed to a decided buff.
White crystalline dolomite: Marble, Lee, Massachusetts.	43.659 44.493	43.625 44.4415	0.034 0.0525	.00077 .0011	No perceptible change.
White crystalline dolomite: Marble, Tuckahoe, New York.	43.442 44.792 46.438 47.053	43.4025 44.7465 46.3815 47.0105	0.0395 0.0455 0.0575 0.0425	.00091 .0010 .0012 .0009	No perceptible change.
Oolitic limestone, Bedford, Indiana.	36.0945 38.3245	34.493 36.4495	1.6015 1.875	.044 .049	Surfaces much roughened and pitted owing to solution of the oolites leaving the fossil fragments and crystalline material of the interstices in relief; arrises strongly attacked.
Oolitic limestone, Bowling Green, Indiana.	38.4375 38.6845	37.1775 37.44	1.26 1.2445	.033 .032	The same, only that the stone is more distinctly oolitic and the surface becomes covered with circular and oval pits.
Oolitic limestone, Salem, Indiana	37.2795 37.45	35.39 35.591	1.8895 1.869	.0506 .050	